Task Y-F008-10-117b
Type C

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PRELIMINARY TESTS OF THE STEPHENSON VALVE

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ABSTRACT

The ~~Naval~~ Civil Engineering Laboratory has designed and tested several blast valves using commonly available resilient materials. One of these, called the Stephenson valve, consists of a steel tube containing polyurethane open cell foam balls. The balls are actually cylindrical in shape, approximately 1-3/4 inch diameter and 1 inch long. A special shock tube was used to test the ability of the valve to attenuate blasts. The valve was 8 inches in diameter and was connected to a 45-cubic foot tank representing the shelter. Shock waves with overpressures up to 90 psi and with positive durations of 2 seconds were applied to the valve. The maximum pressure recorded in the "shelter" was 2 psi. Air flow tests were also made on the 8-inch valve and it was calculated that a 48-inch diameter valve could transmit 1200 cfm of air with a pressure drop of 0.175 inches of water. This valve is also capable of filtering dust from the air but no tests were made to determine dust arrestance characteristics.

A

INTRODUCTION

Blast valves which have been accepted as satisfactory for personnel shelters range from fairly simple to rather complicated mechanisms, but they are all relatively expensive when compared to the cost of the shelter. A simple inexpensive valve is needed and in an attempt to meet this need, NCEL has designed several valves using commonly available resilient materials. Preliminary results of one of these valves is discussed in this note.

DESCRIPTION

The Stephenson valve concept is shown in Figure 1. The 8-inch vertical steel pipe contains a 2-foot column of polyurethane open cell foam balls. When subjected to overpressure these balls compress to seal off the air flow and during normal ventilation they act as a dust filter. The balls are actually cylindrical in shape, approximately 1-3/4 inch diameter and 1 inch long. They are supported on the bottom by a perforated steel plate, fixed to the pipe, and are kept in place on top by a similar plate also fixed to the pipe. Balls of other shapes and sizes will be tested in the future.

PROCEDURE

Test A. To Evaluate the Ability of the Valve to Attenuate Blast Pressure

Test A was made with the NCEL Special Purpose Shock Tube and a 45-cubic foot steel tank which represented the shelter. The set up is shown in Figure 2. Operation of the equipment is briefly as follows: When the plug valve is opened, compressed air from the supply tank rushes into the void above the diaphragm. Soon the diaphragm can no longer support the additional load and bursts, thus creating a shock which strikes the foam balls. Immediately vents 1 and 2 open allowing the air to escape, thereby causing the pressure on the balls to decay in an exponential manner. During the test, temperatures and pressures were measured above the foam and in the shelter. Twenty-three shots were made with overpressures between 10 psi and 90 psi. From this data the peak shelter pressure was plotted against peak overpressure (Figure 3) for a shock wave with a 2-second time duration.

Discussion of Results of Test A

Figure 3 indicates that the shelter pressure rises gradually as the overpressure increases. However, the shelter pressure did not exceed 2 psi even when the overpressure was 90 psi.

Test B. To Determine the Pressure Drop Across the Valve

Figure 1 shows the set-up which was used to measure air flows and the static pressure drop through the valve. Sixteen readings were taken with air flows between 13 and 95 cfm; the test equipment limited flows to 100 cfm.

Discussion of Results of Test B

The valve with a 1-square foot cross-sectional area and a 2-foot depth gave a flow of 95 cfm at a pressure drop of 0.175 inches of water. See Figure 4. Since the air flow through the valve for a given depth and pressure drop is directly proportional to cross-sectional area, it was possible to calculate the diameters of valves 2 feet in depth, which would be required for various air flows if the pressure drop were 0.175 inches of water. At 1200 cfm the diameter would be 48 inches. The results of these calculations are shown in Figure 5.

FINDINGS

1. A 2-foot depth of foam balls when subjected to moderate shock waves showed excellent shock attenuation.

2. Air leakage through the foam under sustained overpressure was very small.

3. It was calculated that a valve 48 inches in diameter will transmit 1200 cfm with a static pressure drop of only 0.175 inches of water.

CONCLUSIONS

The results were quite encouraging and justify further work which is now underway.

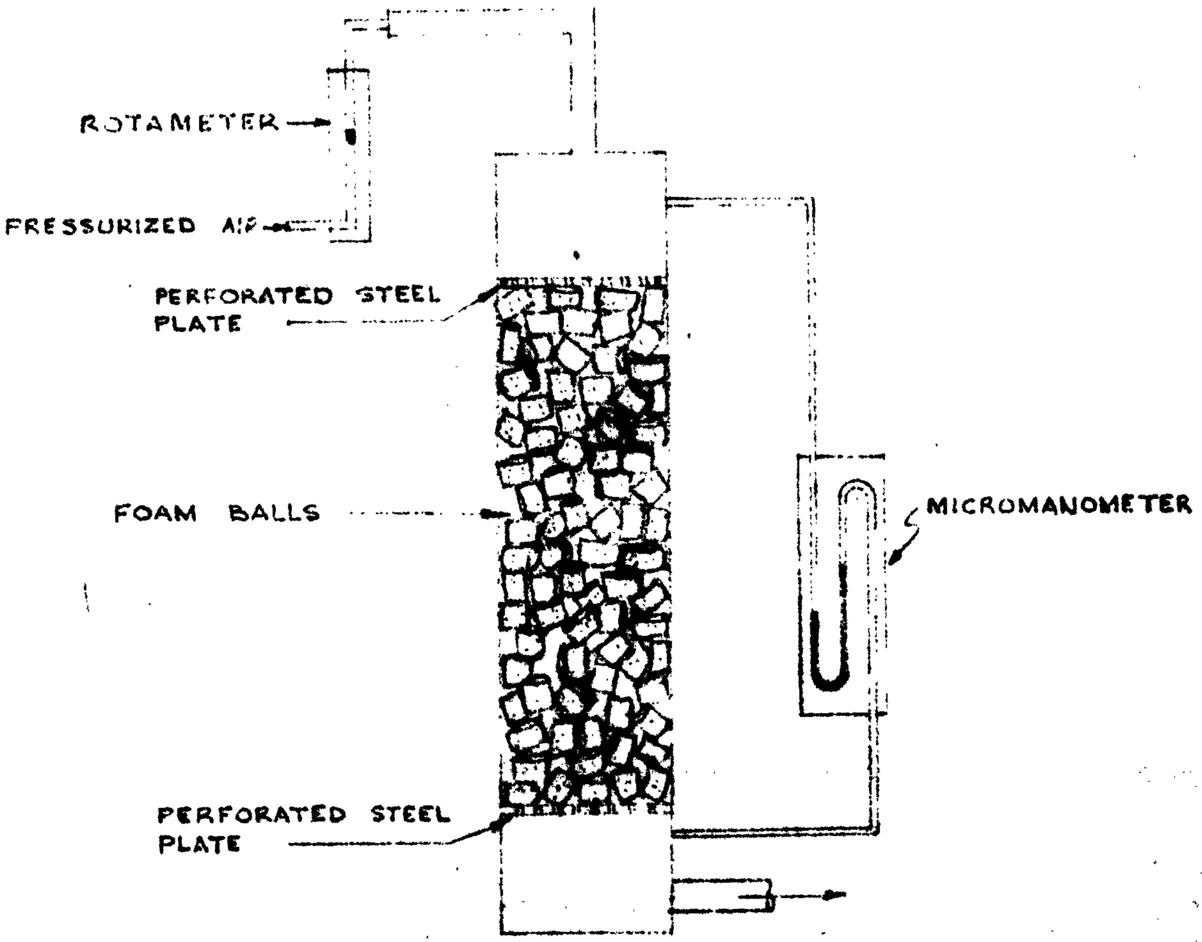
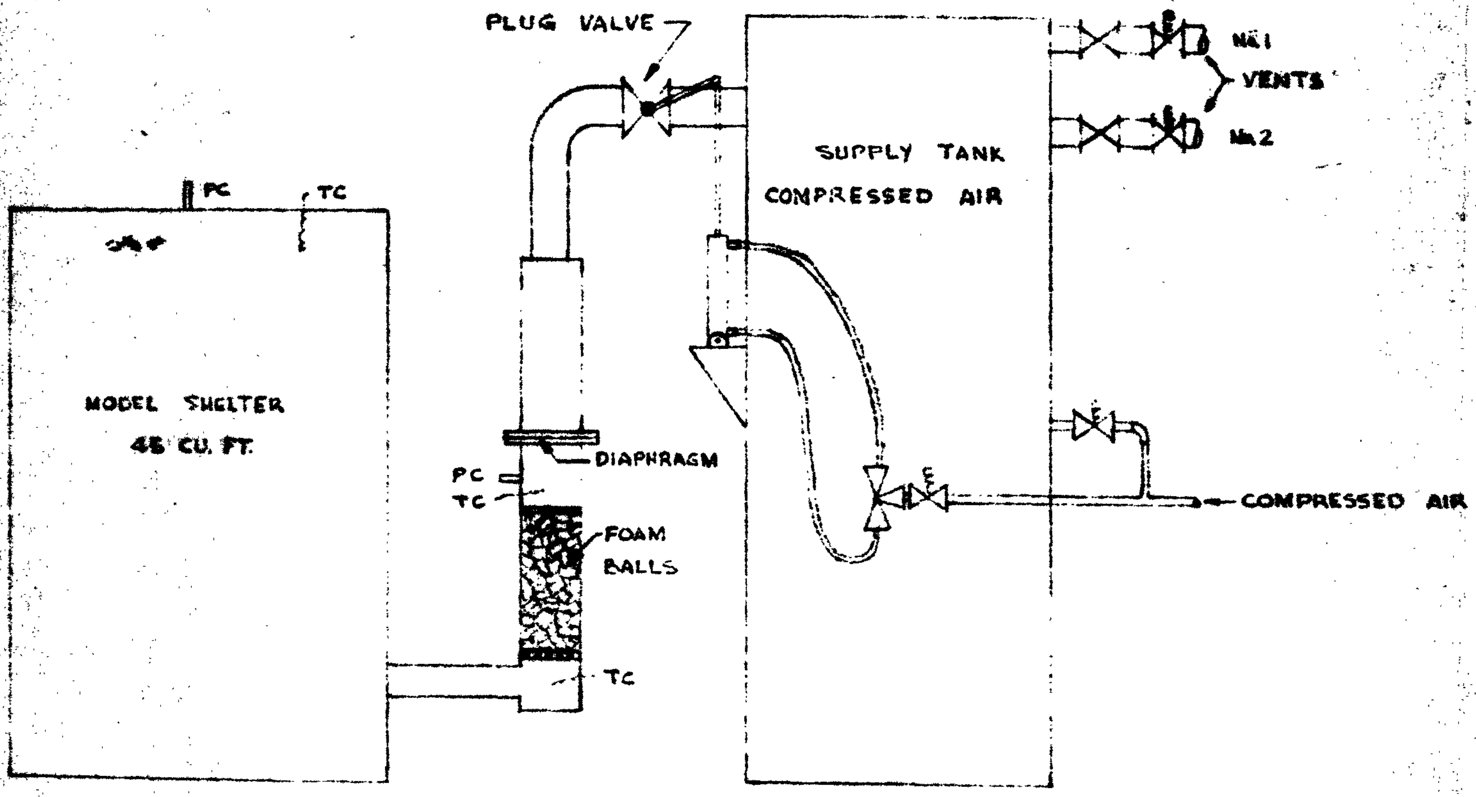


FIG. 1 TO MEASURE STATIC PRESSURE DROP ACROSS STEPHENSON VALVE



PC - PRESSURE CELL
TC - THERMOCOUPLE

FIG. 2 EQUIPMENT TO MEASURE BLAST ATTENUATION

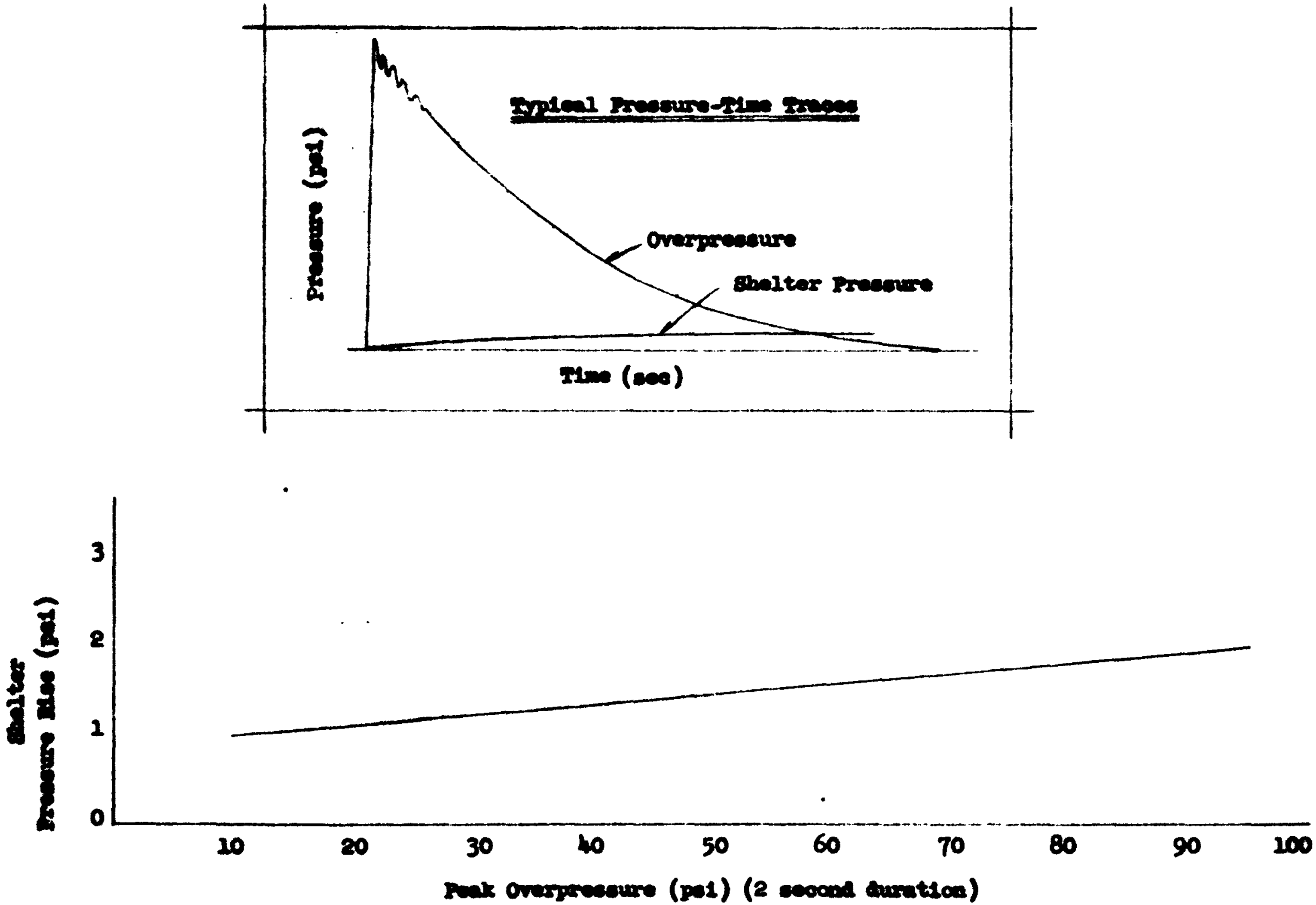


Figure 3. Blast Attenuation Characteristics of the Stephenson Valve

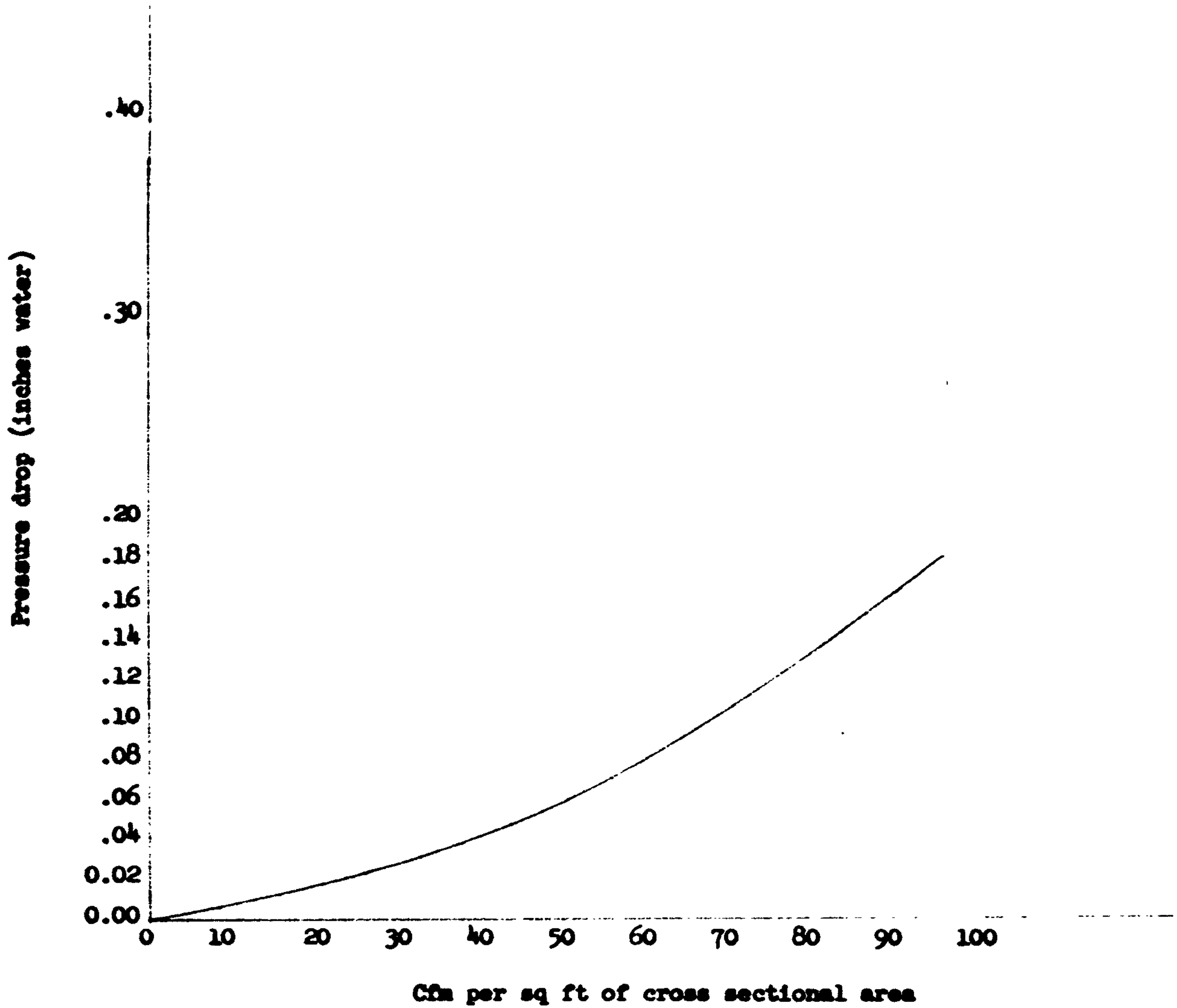


Figure 4. Air Flow Characteristics of the Stephenson Valve

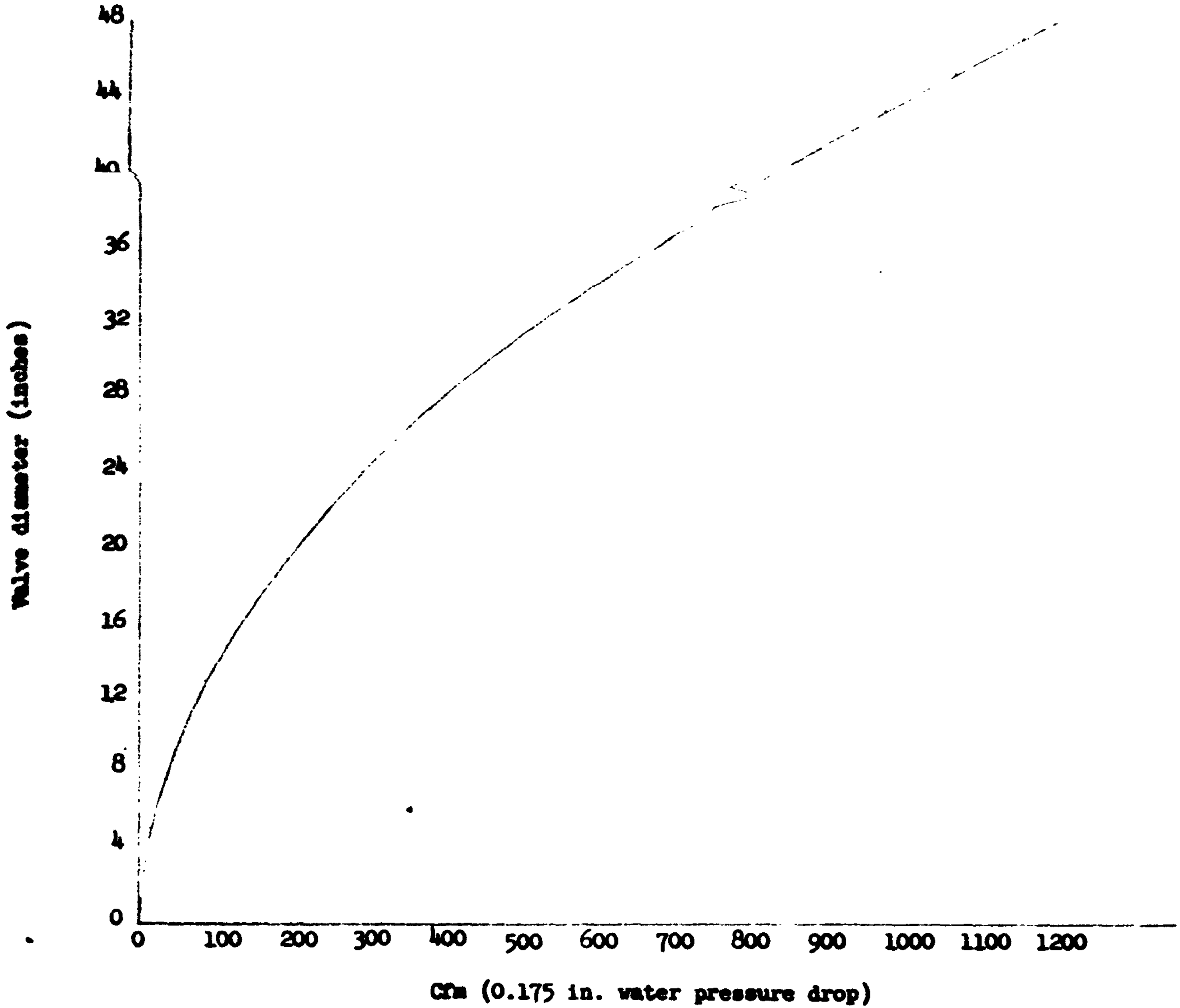


Figure 5. Valve sizes required for air flow rates up to 1200 cfm